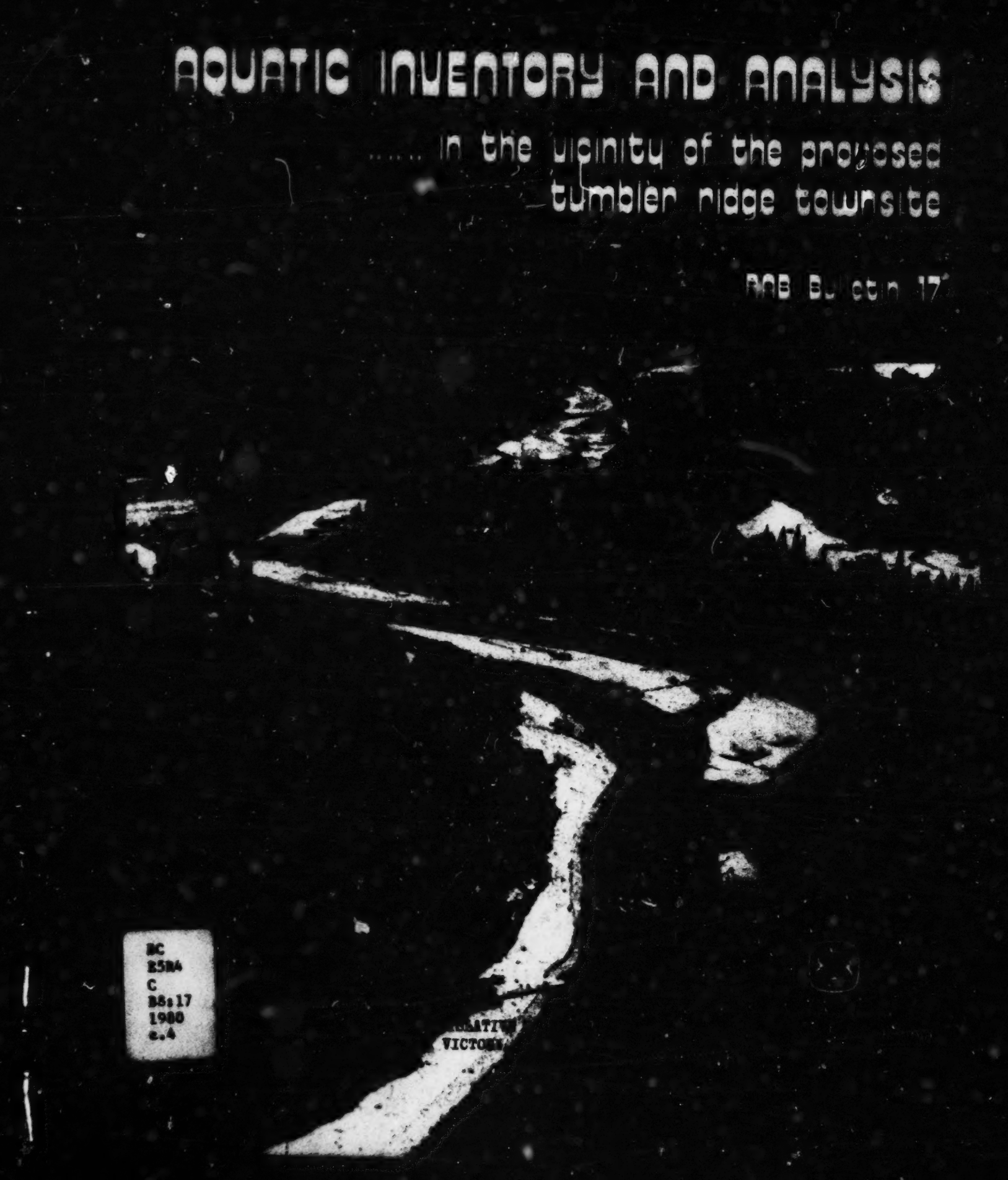
AQUATIC INVENTORY AND ANALYSIS

..... in the vicinity of the proposed tumbler ridge townsite

FRB Bulletin 17



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COVER PHOTO:
Confluence of the Wolverine and Murray Rivers, looking north.

THIS REPORT HAS BEEN PREPARED FOR THE NORTHEAST COAL STUDY AND IS BASED ON PROGRAMS WHICH HAVE BEEN JOINTLY FUNDED BY THE MINISTRY OF ECONOMIC DEVELOPMENT (PROVINCE OF BRITISH COLUMBIA) AND THE DEPARTMENT OF REGIONAL ECONOMIC EXPANSION (CANADA).

Province of British Columbia
Ministry of Environment
RESOURCE ANALYSIS BRANCH

RAB Bulletin 17

AQUATIC INVENTORY AND ANALYSIS IN THE VICINITY OF THE PROPOSED TUMBLER RIDGE TOWNSITE

a technical supplement to the
Northeast Coal Study
Preliminary Environmental Report on
Proposed Transportation Links and Townsites

prepared for
the Environment and Land Use Sub-Committee
on Northeast Coal Development

by
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January 18, 1980

Mr. Raymond L. Crook
Chairman
Environment and Land Use Subcommittee
on Northeast Coal Development
c/o Environment and Land Use Committee
Secretariat
777 Broughton Street
Parliament Buildings
Victoria, B.C.

Dear Sir:

I hereby submit to you the report entitled "Aquatic Inventory and Analysis in the Vicinity of the Proposed Tumbler Ridge Townsite", which has been prepared by my staff for the Northeast Coal Study.

A report on the regional hydrology of the Northeast Coal Block is currently in preparation and when finalized, will complete the Resource Analysis Branch's commitments respecting the Northeast Coal Study aquatic resources program.

Sincerely

W. Arthur Benson

W. Arthur Benson
Director

ACKNOWLEDGEMENTS

The authors wish to acknowledge those individuals who have contributed variously towards the direction, planning, data gathering and report preparation phases of this project: Tom Chamberlin, Dan Davies, Gerry Oliver and Mike Krastman (Resource Analysis Branch); and Ray Crook (E.L.U.C. Secretariat).

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chapter one

1 INTRODUCTION

1.1 BACKGROUND

Within the Northeast Coal Block of British Columbia, a site near Tumbler Ridge (at the confluences of the Murray River with three major tributaries - the Wolverine River, Bullmoose Creek and Flatbed Creek) is being considered for possible town development (see Figure 1.1.). The town would serve various proposed coal mining operations. As part of the Northeast Coal Study, the aquatic systems in the vicinity of the Tumbler Ridge townsite have been investigated in detail by the Environment and Land Use Sub-committee on Northeast Coal Development.

This published report represents an edited and modified version of a report which was originally submitted in draft form in the fall of 1977 to the Townsite/Community Development Sub-committee on Northeast Coal Development. The findings of a regional hydrologic analysis were included in that initial draft (as Chapter Three). For present purposes, however, the hydrologic analysis will be published separately in a report which is tentatively entitled: Regional Hydrology of the Northeast Coal Study Area (Miles, 1980, in preparation).

The present report describes the more important characteristics of the aquatic environment in the vicinity of the proposed Tumbler Ridge townsite. The information is intended to provide a framework within which an assessment can be made respecting:

(i) the potential effects of fluvial processes on the proposed townsite development; and

(ii) the corollary impacts of the townsite development on the aquatic systems themselves.

The study of 'aquatic systems' encompasses the disciplines of hydrology, hydraulics, fluvial geomorphology and biology. In consequence, the scope of this report is broad, including flooding hazard, channel bank and valley wall stability, vertical channel stability, and fisheries resources. As noted above, an analysis of the available hydrologic data has also been undertaken in order to estimate the potential magnitudes of peak discharge events, and also of other types of hydrologic parameters. This work will be reported elsewhere (Miles, 1980, in preparation).

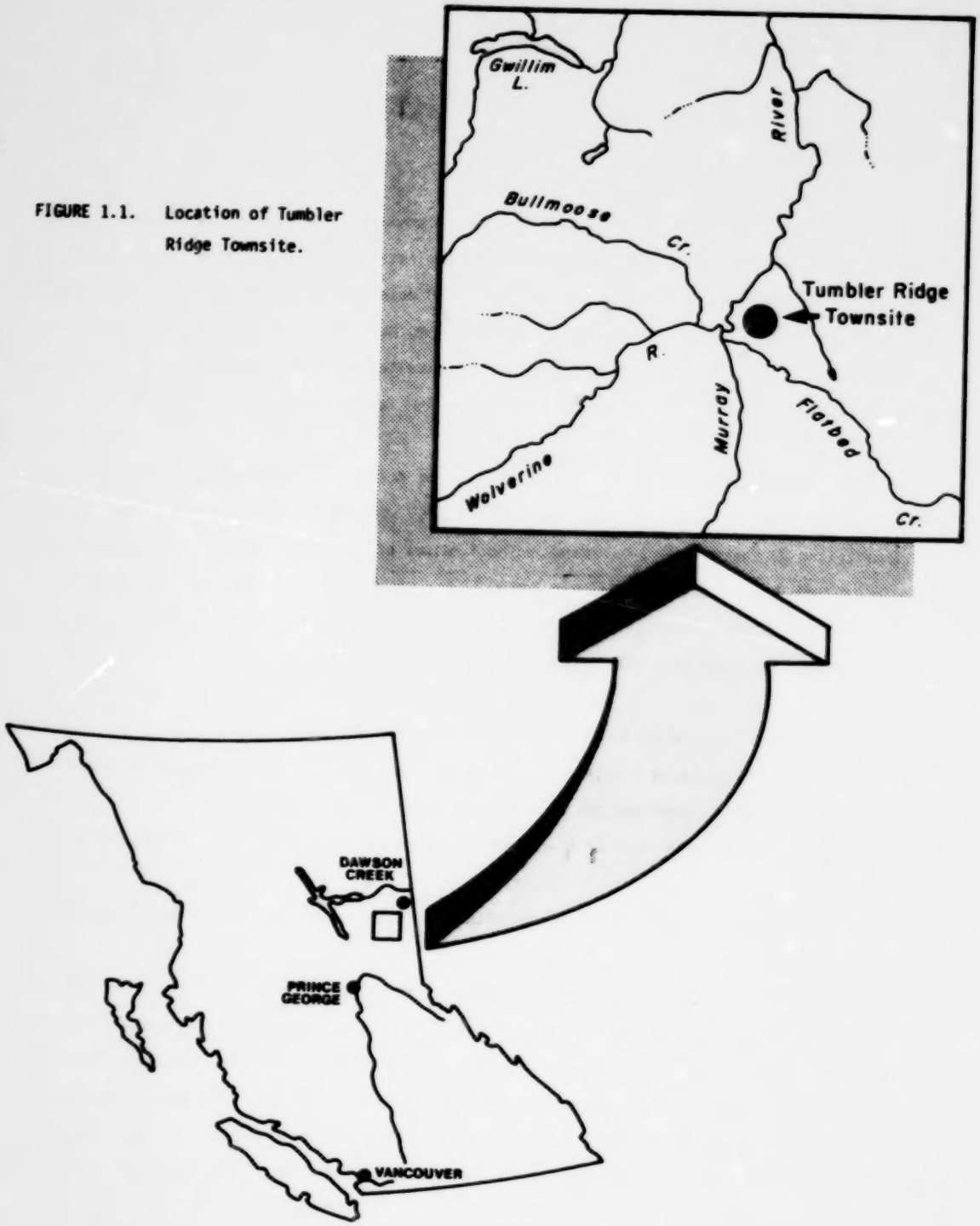

FIGURE 1.1. Location of Tumbler Ridge Townsite.

1.2 CONTENTS OF THIS REPORT

Initially, the present report provides an evaluation of the morphologic and physical characteristics of the Study Area (Chapter Two). This forms a basis for the projection of potential flooding hazard (Chapter Three). The floodplain mapping technique which is used in this analysis is somewhat experimental and, for this reason, the enclosed map (Figure 3.1.) does not meet the legal requirements of either the Federal Flood Reduction Program or provincial floodplain development policies and guidelines. However, the method which is employed is thought to be appropriate for the perceived needs of this study, and represents a considerable saving in manpower and funding resources over those required for conventional engineering techniques of floodplain mapping.

Historic rates of channel migration and valley wall recession have been documented in order to provide a framework within which to evaluate possible set-back limits for development. The findings also form a basis for evaluating the long-term stability of specific sites of concern adjacent to the townsite (Chapters Four and Five). A discussion of vertical stream stability is then provided, since potential vertical changes could affect lateral stability (Chapter Six).

Finally, an investigation of the present distribution of fish has been conducted in order: (i) to identify those fish which are found adjacent to the townsite; and (ii) to illustrate the inter-relationships between various habitat types, and the utilization of these habitats by fish (Chapter Seven). This information makes it possible to delineate precisely those areas which are essential to the continuing existence of the fisheries resource.

chapter two

2 PHYSICAL SETTING

2.1 INTRODUCTION

The proposed townsite is located on the eastern (or right) bank of the Murray River, near its confluences with the Wolverine River and Flatbed Creek. Within this area, there are five reaches (or relatively uniform sections of river) which may be expected to interact significantly with the proposed town development.

2.2 METHODOLOGY

The nomenclature for morphologic characteristics which is employed in the following descriptions follows the standardized and widely accepted definitions of Kellerhals, Church and Bray (1976). Readers who are not familiar with any of the terms may wish to consult that paper for examples of specific definitions, such as those dealing with channel pattern. In general, however, the terms are self-explanatory.

A point which deserves mention concerns the apparent width of the valley flat, or that area which is comprised of the floodplain and associated lower-elevation terraces. It is customary to describe the width of the valley flat as "narrow" if it is less than the average river width, "moderate" if it is one to five times the average river width, and "wide" if it is greater than five times the average river width.

When the terms "low", "moderate" and "high" are applied to bed load transport or to rates of lateral erosion, they are employed in a relative sense, and are primarily intended for comparison between the areas or sites under study. Specific rates of lateral recession are also reported in quantitative terms in Chapters Four and Five.

References to grain size are taken from the Wentworth Scale, and follow the standard usage of the Environment and Land Use Committee Secretariat Terrain Classification System (1976).

2.3 DESCRIPTION OF SIGNIFICANT REACHES

2.3.1. THE LOWER REACH OF FLATBED CREEK

This reach features an irregularly meandering channel which is 'frequently confined' and which is flowing within a 'wide' valley flat. The average channel width is approximately 35 metres. Numerous relict channels are visible on aerial photographs, indicating a historic pattern of meander progression and cutoff. The youthful stages of vegetation succession which are found on point bars suggest that this reach remains laterally unstable and is presently exhibiting low to moderate rates of erosion.

The left-bank valley walls (looking downstream) are fully vegetated and appear stable under the present conditions. The valley walls along the right bank are incompletely vegetated, which is probably a reflection of the southern exposure; they are stable except in one localized, unvegetated section which, although beyond the reach of the present channel, is currently experiencing failure through mass wastage processes.

The bed material is primarily composed of gravelly cobbles, and the presence of recently-deposited channel-side bars and point bars likely indicates that moderate to high rates of bed load transport are occurring. During fieldwork in mid-July of 1977, suspended sediment concentrations were visually estimated to be substantially higher than those which were observed within the Murray River.

2.3.2. THE ADJOINING UPSTREAM REACH OF FLATBED CREEK

This reach contains a virtually 'continuously confined', irregular channel of approximately 30 metres in width. Due to the generally incised character of the reach, the rates of channel migration are very low. The valley walls are generally well vegetated, although instability may be observed at those meander bends where river undercutting is evident. The rates of valley wall recession appear to be very slow, and should not pose any significant technical problems for town-related developments.

The bed material consists primarily of gravels. The absence of bar forms indicates that small to negligible volumes of bed load are accumulating within this reach.

2.3.3 THE LOWER REACH OF THE WOLVERINE RIVER

This reach contains an irregular channel of approximately 30 metres in width, and flowing over a low-angle alluvial fan. Near the apex of the fan, the channel is 'confined' by high, but stable, terraces and resistant bedrock outcrops. Downstream, the channel is 'unconfined' and has undergone numerous 'avulsions' (or major channel relocations) such as typify actively-aggrading alluvial fans. The most recent avulsion probably occurred during 1972 and, at the present time, the river is continuing to adjust to that channel relocation. Thus, moderate to high rates of lateral erosion are presently evident.

The bed material consists primarily of gravelly cobbles. The presence of both active bar forms and the characteristic pattern of lateral instability indicates that high rates of bed load transport are occurring. If this behavior continues, it is extremely likely that additional channel avulsions will occur within this reach in the future.

2.3.4 THE MURRAY RIVER ABOVE FLATBED CREEK

This reach contains a sinuous channel of approximately 60 metres in width, and flowing within a 'moderately wide' valley flat. The river is 'occasionally confined' by the valley walls, and in general, is undergoing low rates of channel migration. The valley walls are well vegetated and appear stable under the present conditions.

The bed material is primarily of gravelly texture. The presence of small, unvegetated channel-side bars and point bars indicates that comparatively low rates of bed load storage occur within this reach.

2.3.5 THE MURRAY RIVER BELOW FLATBED CREEK

This reach contains an irregularly meandering stream of approximately 70 metres in width, and flowing within a wide valley flat. The channel is 'frequently confined' by the right-bank valley wall, while the left bank is essentially 'unconfined'. Both valley walls are generally well vegetated. However, undercutting by river action has resulted in localized instability along the right bank. These undercut areas frequently fail as large slump blocks; this would pose a

significant danger to structures located close to the valley wall.

The presence of various stages of point bar vegetation succession, together with the existence of numerous relict channels, suggests that high rates of meander progression and cutoff are occurring within this reach.

The bed material is primarily a cobbly gravel, and is therefore substantially coarser than that in the reach immediately upstream. The presence of numerous unvegetated bar forms indicates that substantial rates of bed load transport are occurring.

chapter three

3 POTENTIAL FLOODING HAZARD

3.1 INTRODUCTION

The map of "Potential Flooding Hazard - Tumbler Ridge Area" (Figure 3.1.) was prepared with the aid of non-engineering procedures for floodplain delineation. Air photo interpretation, in conjunction with a field investigation of terrain and hydrologic characteristics, has formed the background for a rapid and inexpensive evaluation of potential flood hazard.

Similar techniques have been utilized in the United States (see Parker, Lee and Milfred, 1970; Wolman, 1971; and Reckendorf, 1973), and the results were generally found to be in close agreement with those derived by using standard engineering procedures.

This alternative approach to floodplain mapping is useful in the Tumbler Ridge area, at least for preliminary layout and design purposes, since the local hydrologic data base is not adequate to determine stage/discharge relationships and flow frequency characteristics with the degree of accuracy required by traditional engineering practices. Moreover, the Tumbler Ridge area is undeveloped, and thus presents a good opportunity to undertake alternative floodplain mapping techniques since the characteristic patterns of landforms, soils and vegetation have not been disturbed.

It must be stressed that, at present, it would not be legally possible to impose zoning regulations based on the results of the current survey. Present federal guidelines, as defined in the recent Environment Canada publication: Hydrologic and Hydraulic Procedures for Flood Plain Delineation (1976), indicate that all floodplain mapping which is intended to meet legal requirements under the Federal Flood Reduction Program should be undertaken using standard engineering practices. The same is true in cases where the Province considers an application to approve subdivisions in floodplains (pursuant to section 93 of the Land Registry Act, RSBC 1960, Chapter 208). Specifically, it should be emphasized that the method which is presented in this chapter for assessment of relative flooding hazard on lands within the floodplain of a river is not that which is used by the B.C. Ministry of Environment in the implementation of its flood damage

prevention programs. The policy of the Ministry of Environment would be to prohibit the construction of any building for residential, commercial or storage purposes (where the goods to be stored would be damaged if affected by floodwaters) within the outer limit of the valley flat along the Murray River (as indicated by heavy black lines in Figure 3.1.) until the findings of further, more detailed studies (using engineering techniques) were known.

However, it may be worthwhile in the future to explore the possibility that a hydrologically and legally sound basis for control of land uses on floodplains could be derived from non-engineering mapping approaches, especially if the costs and time involved could be dramatically reduced. Such initiatives are now underway in the U.S.A., as reported by Dingman and Platt (1977).

3.2 METHODOLOGY

The map of "Potential Flooding Hazard - Tumbler Ridge Area" (Figure 3.1.) was prepared after an evaluation of field characteristics within the Study Area. Factors such as soil profile development, the depth and relative decomposition of the litter layer, the pattern of vegetation succession, the presence of fluvially-deposited debris, and the elevation and morphology of the valley flat were evaluated (see Table 3.1.) in conjunction with an investigation of the magnitude of potential discharges (see Miles, 1980, in preparation).

The combinations of field characteristics which were used to define each map unit are tabulated in Table 3.1. It is very difficult to determine flood return intervals in areas which are subject to infrequent inundation. For this reason, the listed recurrence intervals have been chosen on an essentially arbitrary basis in order to indicate the relative frequency with which each unit might flood.

The units which are subject to "frequent" flooding are part of the active channel, and are therefore expected to be inundated during conditions of 'bank-full discharge', which are thought to recur every two to three years. The units which are designated "occasional" will flood only during discharges which are greater than 'bank-full'. The observed field characteristics indicate that these areas are subject to repeated flooding, and suggest that these units will be completely flooded at least once every fifty years.

The units which are designated "rare" will flood only during substantially higher discharges. The location of the outer limit of this unit is difficult to predict and, in general, has been plotted along obvious breaks in slope. This technique is thought to be a conservative but not unreasonable approach, given the magnitude of the probable maximum flood, the observed high rates of channel migration, and the potential for channel blockage due to valley wall collapse.

Units which are termed "unlikely" are not believed to be subject to flooding under the present hydrologic regime.

TABLE 3.1.

CHARACTERISTICS OF FLOODPLAIN MAPPING UNITS

MAP UNIT[1]	LITTER COVER	OVERBANK DEPOSITS, ETC.	FLUVIALLY TRANSPORTED DEBRIS	VEGETATION	TERRAIN HEIGHT	TERRAIN UNIT	'ESTIMATED' FLOOD FREQUENCY
F - FREQUENT	None; or a thin layer of non-decomposed material.	Presence of recent silt or sand deposits. Occasional scour holes.	Fluvially deposited logs and organic debris along channel banks. Occasional debris in lower branches of trees.	None; or species typical of primary colonization; or species typical of wetlands.	Low-lying areas.	Active floodplain, including active channels, side-channels, drainage channels and areas of marsh or swamp.	1- to 3-year return interval.
O - OCCASIONAL	Thin litter cover present, ranging from 'recent' to partly or completely decomposed material.	Silt and/or fine sand deposits, interbedded with organic litter.	Fluvially deposited logs and organic debris may be present on the ground and in the lower branches of trees.	Mature trees, possibly including some species typical of primary colonization.	Areas of moderate elevation.	Area of valley flat dissected by back-, side-, and drainage channels.	Less than 50-year return interval.
R- RARE	Thick litter cover. Lower layer completely decomposed.	No evidence of 'recent' overbank deposits.	Not present.	Mature trees.	Areas of higher elevation.	Areas of low terraces, alluvial fans, or colluvial deposits.	In the range of 50- to greater than 200-year return interval.
U - UNLIKELY	Thick litter cover. Lower layer completely decomposed. Soil profile development is evident.	No evidence of 'recent' overbank deposits.	Not present.	Mature trees.	Areas of higher elevation.	Areas of higher terraces, alluvial fans, colluvial deposits, etc. Usually adjacent to the valley walls.	This unit is unlikely to be flooded under the present hydrologic conditions.

[1]See Figure 3.1. for locations of map units.

3.3 DEPTH OF RECENT FLOODING

Plates 1 and 2 illustrate locations which are typical of the 'occasionally' flooded areas of the Murray River floodplain. The organic debris which has been entangled in the lower branches of trees indicates that the depth of recent inundation has been at least 1.3 metres over areas which were themselves 1.4 to 2.0 metres above the July 14th, 1977 river level. The velocity of water flowing over the floodplain in some areas was sufficiently great to cause scour holes. This is especially evident in portions of the floodplain on the opposite side of the river from sites of major valley wall slumping.

Floodwaters in the lower reaches of the Wolverine River have also over-topped the floodplain by as much as one metre. This is particularly obvious in the vicinity of the previously noted channel avulsions (see Chapter Two, section 2.3.3.). Flatbed Creek does not exhibit the same obvious indications of recent submergence, but it is not known whether this reflects a lower level of discharge or a lack of marker material.

Plate 1

Typical example of the depth of recent flooding over the 'occasionally' flooded areas of the Murray River floodplain.

Plate 2

Typical example of the depth of recent flooding over the 'occasionally' flooded areas of the Murray River floodplain.

3.4 SUMMARY

1. The entire valley flat (that area bounded by steep valley walls) adjacent to the Tumbler Ridge townsite is potentially subject to flooding. A detailed delineation of the expected flooding distribution within this region is presented on the map of "Potential Flooding Hazard - Tumbler Ridge Area" (Figure 3.1.).

2. For the benefit of those planners who are familiar with the Bauer System of river classification, the following units are essentially equivalent:

MAP UNITS	BAUER DEFINITIONS*
"Frequent"	"Streamway"
"Occasional"	"Floodway", and part of the "Floodway Fringe"
"Rare"	"Total Floodplain"

* After Bauer, 1978

3. The presence of fluvially-deposited organic debris indicates that recent floodwaters have over-topped, by at least 1.3 metres, those areas of the floodplain which are subject to 'occasional' inundation.

4. The velocity of water flowing over these 'occasionally' flooded units has been sufficiently great to cause local scouring. This is particularly apparent in areas on the opposite side of the river from past sites of major valley wall collapse.

3.5 RECOMMENDATIONS

1. The potential extent and depth of flooding along the rivers in the vicinity of the Tumbler Ridge townsite dictate that proposed development within these areas must be carefully considered. In the future, it may be possible to flood-proof some of this area with the aid of structures such as dykes and training works. However, given the present undeveloped nature of the floodplain, it would be advisable to implement zoning such that proposed developments would be limited to activities and structures which are compatible with the present hydrologic regime of the valley flat. This would avoid the problems of floodplain management which are currently being experienced by the Federal Flood Reduction Program, and also the unforeseen complications and expense which are inherent in major engineering protection works.

2. In the absence of detailed site-specific hydrologic data, the following preliminary zoning recommendations are felt to be appropriate, given the present knowledge of the local hydrologic regime, although other factors, such as surficial geology, soils, etc., should also be considered in any development suitability zoning concept:

   (i) areas of 'frequent' flooding are essentially part of the active channel; these areas are not therefore suitable for development;

   (ii) areas of 'occasional' flooding will be subject to repeated inundation by floodwaters of low to moderate velocity; development should be limited to essential structures which will not be adversely affected by periodic flooding; development in this area should be minimized in order to avoid both the direct financial loss resulting from peak discharge events, and the subsequent demands for costly structural protection;

(iii) areas of 'rare' flooding will be subject to inundation during exceptionally high flows; permanent structures which are planned for this area should be located on the highest available ground, and should be suitably flood-resistant; it is recommended that development within this region should be discouraged, only being undertaken after the potential flooding hazard has been recognized; additional fieldwork and observations of actual flooding during peak discharge events may justify re-classification of some parts of these units from 'rare' to 'unlikely'; this is particularly true in the area to the south of Flatbed Creek;

(iv) areas which are 'unlikely' to flood are not expected to be subject to flooding hazard under the present hydrologic regime; these areas are therefore suitable for most types of development; and

(v) intermediate units should probably be zoned in accordance with their dominant characteristics, while permitting the option to consider their intermediary characteristics in specific instances.

It must be stressed that, where possible, development planning within the floodplain, as defined in Figure 3.1., should be preceded by the collection of site-specific discharge data. Present government policy would dictate that no development be permitted within any of the four individual floodplain zones prior to more detailed hydrologic investigations.

3. Structures which traverse the valley flat must be carefully evaluated in order to ascertain their effects on the hydraulic and hydrologic regime of both the river channel and its associated floodplain. Such effects may be significant since a change in the frequency and extent of flooding will exert detrimental influences on the ability of the floodplain to serve as habitat for the fish and wildlife species which currently inhabit this area. It should be noted that this chapter does not attempt to formulate conclusions on development zoning suitability in the context of broader resource management issues such as those related to forestry, wildlife, fisheries and outdoor recreation.

chapter four

4 LATERAL STABILITY – CHANNEL BANKS

4.1 INTRODUCTION

The rapid rates of lateral channel migration which are presently witnessed within the Murray River floodplain are of sufficient magnitude to warrant special consideration during the initial planning stages of developments in this area. In addition, the periodic channel shifting which has occurred along the lower reach of the Wolverine River poses a serious hazard to any structure located within its potential range. A detailed investigation into the pattern of recent channel movement has been undertaken in order to estimate both the rates of channel migration and the probable future behaviour of the streams in the vicinity of Tumbler Ridge.

4.2 METHODOLOGY

Historic rates of channel migration have been estimated on the basis of a comparison of aerial photography flown in 1942, 1955 and 1976. The successive positions of the channel were compared with the aid of a Bausch and Lomb "Zoom Transfer Scope" which permits the superposition and rectification of two aerial photographs of different scales. Net channel displacements were then measured on a digitizing table with spot checks on net displacement being achieved with the aid of a Leitz 8-times magnifying measurer.

The reported figures represent average values of the maximum channel migration which has occurred at the indicated location. Small discrepancies between the estimated 1942-1976 migration and the sum of the 1942-1955 and 1955-1976 displacements reflect the errors inherent in making detailed measurements on relatively small-scale photography.

4.3 COMPUTED RATES OF EROSION

The computed rates of channel migration are summarized in Table 4.1., and locations of channel migration are plotted on the map entitled "Lateral Channel Bank Stability - Tumbler Ridge Area" (Figure 4.1.). Where values are omitted from Table 4.1., this reflects poor air photo coverage at the site of interest.

Significant rates of erosion (up to 190 metres in 34 years) are being experienced on the outsides of all meander bends which are located within the low-lying areas of the Murray River valley flat. Substantially lower rates of erosion occur in areas where the meander bends are 'confined' by the valley walls. Much of the material which is eroded from these meander bends is being deposited on the point bars immediately downstream. Thus, high rates of erosion on the outer or 'undercut' banks of meander bends are generally associated with high rates of aggradation on the inner banks of downstream bends.

The highest rates of channel migration are associated with sites #18 to #21 (see Figure 4.1.), and probably reflect the effects of partial channel blockage by slump blocks originating from the valley wall. (This topic is discussed at greater length in Chapter Six). Rates of lateral migration of the Murray River channel upstream of Flatbed Creek are generally low due to the relative height of the channel banks in this area. This reach of the Murray River is illustrated in Plate 3. Exceptions to this generalization occur at sites #2 and #3, where the channel banks are again formed of low-lying materials.

The lower reach of the Wolverine River has recently undergone a complete relocation of its channel. Prior to 1970, the river flowed through an obvious scar to enter the Murray River downstream from site #9. Photography which was taken in 1973 shows the river in its present course (Ker, Priestman, 1977). This channel avulsion likely occurred during the period of exceptionally high discharge in June of 1972.

Channel migration along the lower reach of Flatbed Creek has been limited to the area immediately adjacent to the Murray River. The position of the channel in the upper portions of this reach has not changed significantly over the 34 years of available photography. The reach immediately upstream of this reach is 'frequently' to 'continuously confined' by its valley walls and is therefore quite stable.

The computed "Average Annual Retreat, 1942-1976" in Table 4.1. represents the average rate of retreat over the measurement period. However, much of the observed recession is likely to be the result of a comparatively small number of high-discharge events. For this reason, the figures of "Average Annual Retreat" do not in fact represent the likely rates of recession which could be expected to occur each year on a regular basis.

TABLE 4.1.

HISTORIC RATES OF CHANNEL MIGRATION

LOCATION	SITE NUMBER	ESTIMATED NET EROSION 1942-1955 (metres/13 years)	ESTIMATED NET EROSION 1955-1976 (metres/21 years)	ESTIMATED NET TOTAL EROSION 1942-1976 (metres/34 years)	AVERAGE ANNUAL RETREAT 1942-1976 (metres/year)	TERRAIN UNIT (FROM TERRAIN ANALYSIS MAPPING)
MURRAY RIVER	# 25	-	-	121	3.6	
	# 24	-	0	4	0.1	
	# 23	-	20-30	26	0.6-0.9	
	# 22	-	69	63	1.8	
	# 21	68	85	151	4.5	s$F1
	# 20	17	157	173	5.1	s$F1 and $sF1
	# 19	15	174	190	5.6	$sF1
	# 18	28	109	136	4.0	s$F1
	# 17	-	47	46	1.4	
	# 16	50	65	116	3.4	s$F1 and $gF^{A}1$
	# 15	-	-	63	1.9	$s F^{A}1$
	# 14	-	73	76	2.2	$s F^{A}1$
	# 13	26	50	72	2.1	$sF1
	# 12	-	10-20	16	0.3-0.6	$gF^{G}t$
	# 11	9	66	72	2.1	
	# 9	-	29	29	0.9	s$F1
	# 4	-	-	0	0.0	
	# 3	22	9	30	0.9	s$F1 and sgFt
	# 2	22	22	44	1.3	
	# 1	-	0	0	0.0	sgFt
FLATBED CREEK	# 8	-	36	35	1.0	
	# 7	-	9	4	0.1	$sF1
	# 6	-	51	51	1.5	
	# 5	-	28	33	1.0	
WOLVERINE RIVER	# 10	17	17	33	1.0	s$F1

NOTES:

1. Sites are plotted on Figure 4.1.

2. Net erosion has been estimated from aerial photography flown in 1942, 1955 and 1976. Each column represents an average value of the maximum recession which has occurred at the indicated location. Omitted values are a result of poor air photo coverage or rates of erosion which are too small to be detected. Inconsistencies between estimates of net erosion at a specific site result from the small scale of the aerial photography upon which the measurements are based. Measurements at site #23 are a 'best estimate only' due to heavy shadow cover on the 1976 photography.

3. Significant rates of channel erosion can be expected to occur only during infrequent periods of high discharge. For this reason, the "Average Annual Retreat 1942-1976" values do not represent the actual rate of recession which may be observed in any one year.

Plate 3
Looking upstream along the Murray River above its confluence with Flatbed Creek; the relatively stable channel banks and valley walls are evident.

4.4 FUTURE CHANNEL STABILITY

The recent channel avulsion along the Wolverine River resulted from the inability of the river to transport its sediment load across the lower gradient of the Murray River floodplain. Thus, it is likely that material which accumulated within the channel prior to a period of high flow caused the river to overtop its banks and eventually to cut a new channel around the previously-deposited sediment. This behavior is typical of aggrading rivers. The 1942 photography shows at least three such abandoned channels on the fan of the Wolverine River, a further indication that this behavior has been occurring for some time. (It is interesting to note that the present channel of the Wolverine River is in essentially the same location as one of the known relict channels).

At the present time, the lower section of the Wolverine River is again infilling through aggradation, and is therefore becoming increasingly unstable. This area is illustrated in Plate 4. It is relatively difficult to predict the behavior of this channel in the immediate future. One obvious possibility is the breaching of the narrow neck of land immediately upstream of the present channel mouth. However, during periods of high flow, it is likely that some portion of the river will find its way through the abandoned 'ox-bow' channel immediately downstream. These alternatives are shown in Plate 5.

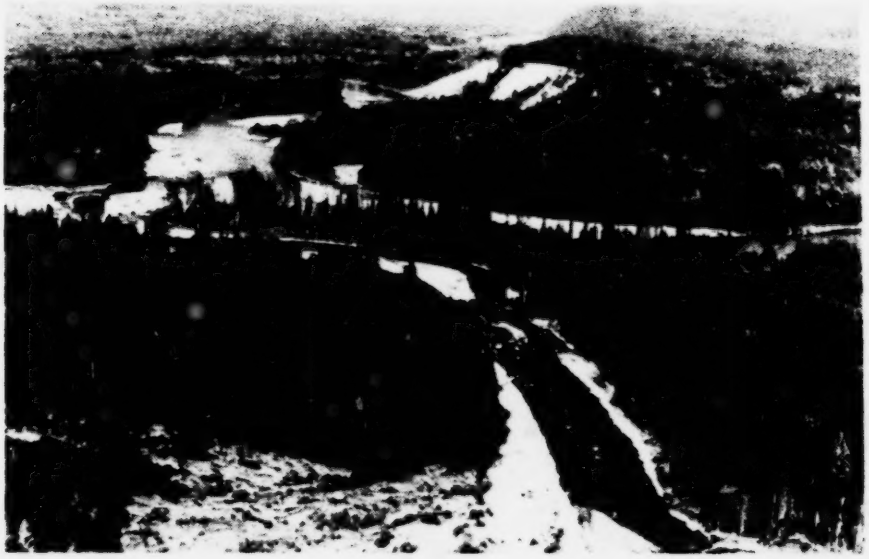

Plate 4

Looking downstream along the lower reach of the Wolverine River. Note the bars which are forming in the channel as a result of the accumulation of sediment.

Plate 5

The mouth of the Wolverine River, illustrating the possible locations of the channel in the immediate future.

Over a longer time period, it is expected that the Wolverine River will again 'avulse' when sufficient material has aggraded in its lower channel. Plate 6 illustrates the entire lower reach of the Wolverine River. The location of the upper section of this reach is fixed due to the relatively high valley walls. The left bank (looking downstream) immediately below this 'confined' reach is also reasonably high, and therefore blocks possible channel migration in that direction. The right bank is significantly lower, and it is conceivable that the river may eventually migrate through this unit until it reaches the higher terrace beyond. (These units are marked U/R and O/R respectively in Figure 4.1.). However, at present, the channel is relatively deeply incised in this region and the rate of channel migration is reasonably slow. Further downstream (in the vicinity of the unit marked R/O), the left bank is substantially lower and the potential for lateral instability is increased. This area forms the upper apex of the numerous historic channels which may be recognized on the 1942 aerial photography.

Plate 6
The lower reach of the Wolverine River in the vicinity of its confluence with the Murray River. Note both the 'plug' of sediment which blocks the abandoned channel of the Wolverine River and the meander bend which will eventually be cut off by the Murray River.

A factor which complicates prediction of the possible future behavior of the Wolverine River is the likelihood that the Murray River will eventually break through the plug of material which occupies the recently abandoned Wolverine River channel. When this event occurs, either all or part of the Murray River will then flow through the present lower channel of the Wolverine River. The resulting increase in channel slope will likely cause a significant increase in the rate of channel migration immediately downstream.

Thus the area around the confluence of the Wolverine and Murray Rivers is potentially highly unstable, and any development in this area must be undertaken with considerable caution.

4.5 FACTORS INFLUENCING CHANNEL BANK STABILITY

Channel bank stability may be affected by numerous factors. The effects of channel blockage due to either valley wall collapse or the presence of aggradational deposits have already been mentioned. Other important considerations include the diversion of river flow by ice or debris jams. No evidence has been found to indicate the historic presence of ice jams. However, the positions and large quantities of logs in these rivers indicate that debris accumulations play an important role in channel stability.

The effects of debris on channel location are dependent upon both position and river stage. Debris which has been deposited at the ends of channel bars frequently acts as a stabilizer and results in the additional aggradation of sediment. During high flows, much of this organic debris may float, forming larger debris jams. These jams frequently lead to increased rates of bank erosion as the river attempts to by-pass them. A number of such log jams are located along the lower reach of the Wolverine River and may have played a significant role in the recent channel avulsion. Extensive debris deposits are also found along the Murray River and may constitute a significant hazard to structures which are planned for this area.

4.6 SUMMARY

1. Historic rates of channel migration have been estimated through the comparison of air photographs taken in 1942, 1955 and 1976. The results of this study are presented on the map entitled "Lateral Channel Bank Stability - Tumbler Ridge Area" (Figure 4.1.), and also in Table 4.1.

2. Rates of channel migration along the low-lying areas of the Murray River have been as high as 190 metres in 34 years. The highest values are located on meander bends opposite areas of major valley wall failure. The lowest rates occur in straight sections of channel or in areas where the river is 'confined' by valley walls. The banks of the Murray River upstream of Flatbed Creek are generally higher, and are therefore relatively stable.

3. The Wolverine River has recently avulsed, completely relocating its channel. This behavior is characteristic of aggrading rivers, and it is likely that this channel will again avulse during the future.

4. The mouth of the Wolverine River is a particularly unstable area, and is expected to undergo significant additional change in the near future. A complicating factor is the likelihood that the Murray River will eventually break through the plug of sediment which presently blocks the former Wolverine River channel. This would permit part of the Murray River to flow along the present channel of the Wolverine River, and would be associated with significant rates of lateral erosion in this area.

5. No evidence was found to indicate that major ice jams have occurred in this area. However, evidence of this type is difficult to detect, and it is not possible to assert that ice jams will pose no problems.

6. Significant quantities of debris are found in the channels of both the Murray and Wolverine Rivers. This material has historically formed sizeable log jams which undoubtedly do affect channel stability.

4.7 RECOMMENDATIONS

1. The high rates of bank erosion which are experienced along the low-lying areas of the Murray River must be considered when planning activities or structures in these areas. The historic rates of erosion which are indicated in Table 4.1. may be used to estimate future rates of channel migration, and also to design appropriate set-back distances.

2. The area adjacent to the lower reach of the Wolverine River is potentially highly unstable. If

possible, development should be restricted to a minimum in this area. If the possibility of bridging the Wolverine River is under consideration, the crossing site should be located as far upstream as practical.

3. A reconnaissance survey of ice thicknesses and break-up conditions should be conducted in the vicinity of the Tumbler Ridge townsite.

4. Bridge design along the Murray and Wolverine Rivers should take into account both the substantial debris load which is carried by these two rivers and the potential for massive log jams at bridge sites during periods of peak flow.

5. Rates of bank erosion are likely to increase in conjunction with development activities involving: (i) the removal of the vegetation cover across the valley flat; or (ii) river training structures which increase the velocity or depth of flow. Thus, any clearing or structural development which is to be located adjacent to the river must be evaluated in terms of its potential effects on channel stability.

chapter five

5 LATERAL STABILITY—VALLEY WALLS

5.1 INTRODUCTION

The valley walls in the vicinity of the Tumbler Ridge townsite are generally well vegetated, and, in their undisturbed condition, are relatively stable. Exceptions occur near five major meander bends where undercutting by the Murray River has resulted in localized instability. The rates of recession at these sites appear to vary, depending upon both the geologic materials in the valley wall and relative exposure to fluvial attack.

The magnitudes of some recent valley wall failures have been considerable. This therefore poses a problem which must be considered during the design of the proposed townsite. For this reason, an analysis of historic rates of valley wall retreat has been conducted in conjunction with the analysis of channel bank stability.

5.2 METHODOLOGY

Rates of valley wall recession have been estimated by means of a comparison of aerial photography taken in 1942, 1955 and 1976. Measurements from these photographs yield an average rate of headwall retreat over the elapsed period. The maximum slump block width which may have been associated with a 'single event' has been estimated by measuring the width of recent 'scars'. This figure is an over-estimate in most cases, however, since the observed scar is probably the result of several smaller failures. Thus, this figure provides an indication of the maximum possible magnitude of the largest single failure which may have occurred in recent times.

5.3 ANALYSIS OF RECENT VALLEY WALL INSTABILITY

The map of "Lateral Valley Wall Stability - Tumbler Ridge Area" (Figure 5.1.) plots the locations of relict, incipient and active sites of valley wall instability in the vicinity of the Tumbler Ridge townsite. It is clear that all major sites of active or incipient failure are associated with river undercutting. Most relict sites reflect historic fluvial activity. The major

'slump' which occurs at location B is an interesting example. At the time of failure (just prior to 1942), this site was being actively undercut. The debris which was produced from the resulting slump block completely infilled one 'branch' of the river, and partially covered a mid-channel island. Thus, the present river is far removed from its position at the time of failure.

Table 5.1. summarizes the morphology, composition and recession rates of the five major sites of valley wall failure. All other sites are retreating at rates which are so low that they are not measurable, given the available scales of aerial photography.

TABLE 5.1.

VALLEY WALL STABILITY

LOCATION[1]	APPROXIMATE HEIGHT (metres)	ESTIMATED MAXIMUM RETREAT, AS MEASURED FROM SUCCESSIVE AERIAL PHOTOGRAPHY			TERRAIN UNIT[2]	CAUSE OF FAILURE	COMMENTS
		1942-1955 (metres)	1955-1976 (metres)	1942-1976 (metres)			
A	100-120	-	-	ca. 5	Rs	Undercutting of bedrock by river action.	The bank is unvegetated. Failure is occurring by sloughing and also by small 'block falls'.
B	80	0	0	0	sgFt/$\frac{sgFvb}{Rb}$	Undercutting of unstable material by river action.	This failure appears to have resulted from a single event which took place immediately prior to 1942. At this time, the river was actively undercutting the site. The maximum width of the present scar is approximately 70 metres.
C	65	ca. 5	ca. 25	ca. 30	sgFt/$\frac{sgFvb}{Rb}$	Undercutting of unstable material by river action.	The maximum possible width of recent slump blocks would be less than 25 metres (based on the depth of visible scars). The area of active retreat has been continuously increasing since 1942. The region immediately north of this site exhibits numerous incipient failures.
D	60	north end 0 south end < 3	40-80 < 2	40-80 < 5	sgFt/$\frac{sgFvb}{Rb}$	Undercutting of unstable material by river action.	The maximum possible width of recent slump blocks would be less than 20 metres (based on the depth of visible scars). The area of active erosion has been steadily expanding northwards since 1942. Approximately 80 metres of erosion has occurred at the top of the terrace, while up to 40 metres of lateral movement has occurred on the terrace flank.
E	70	neck of land - west end 0	- -	20 15	sgFt/$\frac{sgFvb}{Rb}$ and sgFt	Undercutting of unstable material by river action.	The face is slowly retreating through basal undercutting and resultant sloughing of the oversteepened face. No slump blocks are apparent on any of the aerial photography. The centre of activity is migrating southwards.

[1]Locations are plotted on Figure 5.1.
[2]Terrain unit designations from 1:20 000 Resource Analysis Branch terrain mapping for the Tumbler Ridge townsite.

Location A (see Plate 7) is composed of relatively poorly consolidated bedrock. Rates of retreat are quite low, and have been estimated to be less than five metres for the 34 years of record.

Location B (see Plate 8) is an inactive site which consists of unconsolidated sands and gravels. Prior to 1942, a single event appears to have resulted in a major failure of up to 70 metres in height. This scar is significantly deeper than any of the others which occur in the Study Area. Since the extent of undercutting was approximately the same as that now occurring in other locations, it must be assumed that the unusual width of this feature indicates the presence of exceptionally unstable materials and/or adverse groundwater conditions such as perched water tables.

Plate 7
Location A, illustrating the low rates of retreat which are associated with exposures of poorly consolidated bedrock.

Plate 8
Location B, featuring an old slump scar 70 metres in height; it likely resulted from a single event immediately prior to 1942.

Location C (see Plate 9) has been continuously active over the period of photographic record. The net recession is relatively difficult to measure due to the scarcity of good photo control points, but an estimate of less than 30 metres appears reasonable. The maximum possible width of a single slump block is approximately 25 metres. The area of active failure has been continuously widening since 1942 and, at present, the area north of location C features numerous incipient failures (see Plate 10).

The focus of active failure at location D (see Plate 11) has been migrating northwards since 1942. The present site was inactive in 1942, but, since then, approximately 80 metres of headwall retreat has occurred in conjunction with 40 metres of retreat on the northern flank of the failure. The maximum width of recent slump blocks is less than 20 metres. The relatively stable scar to the south of this site was active in 1942, and, since that time, has undergone less than five metres of retreat.

Plate 9

Location C, demonstrating the extent of active failure.

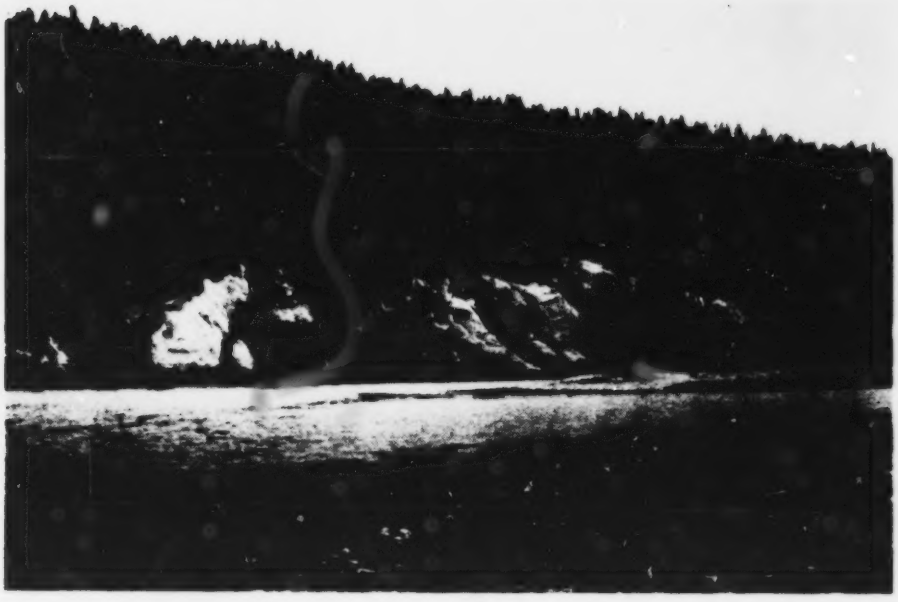

Plate 10

Incipient failures immediately upstream of Location C.

Plate 11
Location D, featuring active undercutting and resultant valley wall failure.

Location E (see Plate 12) forms one side of a narrow neck of land adjacent to the Tumbler Ridge townsite. The minimum width of this terrace remnant has decreased by approximately 20 metres since 1942. However, the site of active erosion has now shifted southwestwards and has caused 15 metres of retreat in the last 21 years on the western margin of the present scar. This site is failing through basal undercutting and resultant facial sloughing. This is the only site which has not undergone 'slump block' failure, and likely reflects the lack of underlying morainal material which is present in all other locations (as indicated in previously published mapping of surficial geology in the Tumbler Ridge area - available from the Resource Analysis Branch).

The valley walls on the southern side of the townsite are generally stable under present conditions, as illustrated in Plate 13. Upstream of this photograph, Flatbed Creek is incised, and the rates of lateral retreat which result from undercutting are too small to be detected, given the available aerial photography.

Plate 12

Location E, featuring basal undercutting and the resultant facial sloughing of debris.

Plate 13

The lower section of Flatbed Creek, illustrating the generally stable valley walls.

5.4 IMPLICATIONS OF VALLEY WALL INSTABILITY

Much of the Murray River valley wall adjacent to the proposed townsite will eventually be attacked by river action if the present rate of channel migration is permitted to continue. As a result of the transient nature of this river action, the observed rates of erosion are not likely to occur in any one place over a duration of more than approximately 50 to 100 years.

An exception to this may occur if river training works associated with one of the potential sites for a Murray River highway crossing fix the position of the channel upstream of location D (see Figure 5.1.). This could potentially lead to sustained rates of valley wall erosion in areas immediately downstream of the bridge. This possibility, together with the potential effect of the resulting valley wall instability, should be considered in the detailed design of both the townsite and that particular bridge proposal.

Another consideration is the potential impact of development (including the effects of clearing, pedestrian and vehicular traffic, alterations of groundwater regime, etc.) on the future stability of the valley walls. Detailed analysis is required since the depth of failure at location B indicates that the material which comprises this terrace may be relatively unstable under certain conditions. Thus, factors such as an increase in groundwater recharge (resulting from clearing and residential waste) may be sufficient to seriously alter the present relatively stable conditions. The likelihood of this occurrence is increased where the material which comprises this terrace is underlain by an impervious layer (such as the reportedly underlying till).

These types of problems are currently being considered in a detailed study of valley wall stability which is being undertaken by consultants Thurber and Associates (of Victoria, B.C.). The information presented in this chapter is intended to provide background material for their report and recommendations.

5.5 SUMMARY

1. Under present conditions, the valley walls in the vicinity of the Tumbler Ridge townsite are generally stable. Exceptions occur at five locations where undercutting by the Murray River has resulted in localized instability (see Figure 5.1. and Table 5.1.).

2. Some of the recent valley wall failures have been of considerable magnitude, so that the rate of valley wall recession should be considered in the design of the proposed townsite.

3. A comparative analysis of aerial photographs which were taken in 1942, 1955 and 1976 was conducted in order to determine the magnitude of valley wall recession which may be expected under present conditions.

   In the vicinity of the poorly consolidated bedrock cliffs along the northern margin of the townsite, the rates of erosion are low, with an estimated retreat of less than five metres over the 34 years of available photography.

   Sites along the western side of the townsite (north of the prominent 'peninsula') have undergone rates of recession totalling 25 to 80 metres during the last 21 years. These sites are composed of fluvially deposited sands and gravels overlying morainal material. Failure frequently occurs here through massive 'slumping'. These slump block are generally less than 20 to 25 metres in width, although in one case, the maximum width was nearly 70 metres.

   The prominent 'neck' or peninsula of land at the southwestern corner of the townsite is failing through a process of basal undercutting and resulting facial sloughing, rather than by slumping. This may reflect a lack of underlying morainal material in this area. Rates of recession are correspondingly slower and appear to total less than 20 metres over the 34 years of photographic record.

   The valley walls on the southern side of the townsite are generally stable under present conditions. Rates of recession in the incised sections of Flatbed Creek are too small to be detected on the available photography.

4. Given the present rapid rates of downstream meander migration on the Murray River side of the townsite, the foci of fluvial attack beneath the valley walls are tending to shift within a period of 50 to 100 years. Thus, under present conditions, the reported rates of erosion are a transient effect and are not likely to occur in any one place over a protracted period.

5. Townsite development may affect valley wall stability if:

   (i) river training works associated with the possible Murray River bridge site above location D fix the location of the channel in such a manner that sustained rates of valley wall recession may occur downstream; or

   (ii) alterations to both the groundwater regime and the surface cover increase the potential instability of the materials which compose these terraces.

5.6 RECOMMENDATIONS

1. The design of the Tumbler Ridge townsite must consider the rates of valley wall recession which are presently occurring as a result of natural processes. These processes could be accelerated as a result of developmental disturbances.

2. The information on historic rates of recession contained within this chapter should provide a useful background against which to assess the potential effects of natural rates of recession on the margins of the townsite in the future.

3. Estimation of post-development recession rates must take into account the effects of both alterations to the groundwater regime and disturbance of the present surface vegetation cover. In addition, the potential effects of river training works associated with the proposed Murray River bridge deserves special attention.

chapter six

6 VERTICAL CHANNEL STABILITY

6.1 INTRODUCTION

An analysis of vertical channel stability normally includes an estimation of scour depths in addition to an evaluation of the long-term pattern of aggradation or degradation. Since potential depths of scour have been calculated for the design of a proposed Murray River bridge crossing upstream of Location D (by consultants Ker, Priestman and Associates, 1977), they will not be re-estimated in this report.

6.2 METHODOLOGY

The comments in this section are derived from aerial photograph interpretation plus a brief survey of the field site. No detailed measurements were undertaken since they are not easily obtained without much more detailed surveys than were attempted here.

6.3 ANALYSIS OF VERTICAL STABILITY

The numerous terraces and incised channels in the vicinity of Tumbler Ridge indicate that the rivers in this area have achieved moderate rates of downcutting during the immediate post-glacial period.

6.3.1 THE MURRAY RIVER

At the present time, the Murray River does not exhibit any obvious indications of net aggradational or degradational behavior. The 'frequently confined' reach of the Murray River upstream of Flatbed Creek is probably degrading at a very slow rate.

Recent studies on the Beatton River (Hickin and Nanson, 1975) indicate that the present rate of degradation along that river is approximately 0.01 metres per year. Values of a similar order of magnitude may be expected in this section of the Murray River.

The 'occasionally confined' reach of the Murray River below the confluence with Flatbed Creek is more difficult to evaluate. The channel slope likely increases in this reach, partially as a response to the high rates of sediment production associated with both Flatbed Creek and the Wolverine River. Recent 'over-bank' (or accretion) deposits are obvious over much of the valley flat. However, rates of lateral migration are high, and result in substantial removal of material from this area. Thus, the processes of aggradation tend to be balanced by processes of degradation.

6.3.2 FLATBED CREEK

Flatbed Creek is behaving in a manner relatively similar to the Murray River, with slow rates of degradation occurring in the upper 'confined' reach, and very slow rates of degradation in the lower 'unconfined' reach.

These observations indicate that these two stream sections are in an essentially 'graded' (or equilibrium) condition and, as such, are not expected to undergo radical changes in vertical stability.

6.3.3 THE WOLVERINE RIVER

The Wolverine River presents a somewhat more complicated situation. The recent channel avulsion (or radical channel relocation) is a result of sediment aggradation in the lower reach of the river. The post-avulsion channel immediately upstream of the new confluence has achieved approximately two metres of downcutting in response to the new 'base level' which was set by the shifting in the position of the channel mouth. The area in the vicinity of the new confluence has again begun to aggrade, as illustrated in Plates 5 and 6. These deposits will eventually extend over the entire lower reach of the Wolverine River, and may result in another channel relocation if they aggrade to a sufficient depth.

6.3.4 WOLVERINE - MURRAY SYSTEM INTERACTIONS

The vertical stability of the Wolverine River will be significantly altered if the Murray River cuts through the plug of material which currently blocks the abandoned Wolverine River channel. If this occurs, a portion of the Murray River will flow through the present lower channel

of the Wolverine River, resulting in significant erosion within both the abandoned channel of the Wolverine River and the channel of the Murray River immediately upstream. As a consequence of this downcutting and the associated lateral instability, it is anticipated that an increased rate of sediment deposition will occur within the low-lying reach of the Murray River immediately downstream. This in turn will cause an increased rate of lateral instability within that area.

6.4 SUMMARY

1. Under present conditions, both the Murray River and Flatbed Creek are either in vertical equilibrium or are undergoing very slow rates of degradation.

2. The Wolverine River is vertically unstable due to continuing deposition of sediment in its lower reach. As a consequence of the recent channel relocation, this reach has subsequently degraded by approximately two metres. Sediment is again being deposited in the reach, and may eventually result in another channel relocation.

3. The potential cutoff along the Murray River may permit a portion of its present flow to pass through the recently abandoned Wolverine River channel. This would result in local channel erosion of between three and four metres, together with concurrent deposition of this material in the reach immediately downstream. Minor rates of degradation would also be expected to occur along the Murray River immediately upstream.

6.5 RECOMMENDATIONS

1. Design criteria for structures which are to be located in the vicinity of the lower reach of the Wolverine River must allow for the possibility of up to four metres of channel degradation within the abandoned channel of the Wolverine River and over adjoining areas. High rates of sediment transport and the probability of eventual major channel relocations should also be taken into account.

chapter seven

7 FISHERIES HABITAT

This chapter discusses the fisheries habitat of streams in the Tumbler Ridge area. The habitat has been classified into zones which are indicated on the map of "Fish Habitat Zones - Tumbler Ridge Area" (see Figure 7.1.). The interpretative sections which follow explain the significance of each habitat zone, and also the inter-relationships between zones.

7.1 FISH SPECIES AND RELATIVE VALUES

Table 7.1. lists the fish species which are present in the Murray, Wolverine and Flatbed systems in the vicinity of Tumbler Ridge. Their presence was confirmed through electro-shocking, seining and angling during the 1976 and 1977 field seasons.

TABLE 7.1.

LIST OF FISH SPECIES

COMMON NAME[1]	SCIENTIFIC NAME[1]
Arctic grayling	Thymallus arcticus
brook stickleback	Culaea inconstans
burbot (ling cod)	Lota lota
Dolly Varden	Salvelinus malma
finescale dace	Pfrille neogaea
longnose sucker	Catostomus catostomus
mountain whitefish	Prosopium williamsoni
northern pike	Esox lucius
slimy sculpin	Cottus cognatus

[1]After Scott and Crossman, 1976.

Table 7.2. summarizes the values which are associated with fish species in the Tumbler Ridge area. This information is useful since there is generally a lack of familiarity with Arctic drainage fish species.

TABLE 7.2.

VALUES OF FISH SPECIES AT TUMBLER RIDGE

SPECIES	CATCHABLE SIZE RANGE	EASE OF ANGLING	FOOD QUALITY	COMMENTS
ARCTIC GRAYLING	15 to 40 cm	easy to angle by all methods, particularly by fly-fishing	high	found in large concentrations; a popular sportsfish species among fly fishermen
BROOK STICKLEBACK and FINESCALE DACE	3 to 5 cm	not angled	forage fish	important forage fish for both pike and Dolly Varden
BURBOT (LING COD)	15 to 30 cm	fair angling, best with bait	excellent	not a highly significant population in this area
DOLLY VARDEN	15 to 80 cm (up to 20 kg)	easy to angle with bait or lure	high	a sportsfish highly prized by most anglers
LONGNOSE SUCKER	10 to 40 cm	not angled	low, but not nil	bottom feeder and scavenger; possibly a forage fish
MOUNTAIN WHITEFISH	15 to 30 cm	fair, but best with bait	fair to good	found in large concentrations; usually caught incidentally while fishing for other species
NORTHERN PIKE	15 to 80 cm (up to 20 kg)	easy to angle by all methods	good	a popular sportsfish throughout a large part of eastern Canada
SLIMY SCULPIN	3 to 10 cm	not angled	nil	a useful scavenger

7.2 FISH HABITAT ZONE MAPPING METHODS

The Study Area for fish habitat classification was defined on the basis of the information on the map of potential flooding hazard (Figure 3.1.). The area of 'frequent' flooding on the flood hazard map has been broken down into four zones by type of channel as follows:

(i) active channels;

(ii) ephemeral channels;

(iii) semi-isolated channels; and

(iv) isolated channels.

These zones were differentiated by means of aerial photography, helicopter observations and fish sampling at representative points.

Within habitat zones, there are smaller units, termed habitat types, which constitute specific locations which fish may occupy. A large variety of habitat types may comprise one habitat zone. No attempt was made to map these habitat types during the present survey, although some discussion of the importance of habitat diversity is contained in section 7.4. (below).

7.3 FISH HABITAT ZONES

7.3.1 ACTIVE CHANNELS

The "active" channel zone contains the main channel, plus side-channels and the numerous minor channels which occur in association with the presence of gravel bars. In the Tumbler Ridge area, active channels are those which are located below the level of rooted streambank vegetation and which contain water for a significant period each year. Typically, these channels are full of water during the period of peak spring discharge, but feature reduced flows during the summer and fall seasons. During the winter, channels other than the main channel are either dry or contain a small or discontinuous discharge only.

Extremely high-quality fish rearing habitat occurs in conjunction with the low water velocities of many of the secondary channels in the Tumbler Ridge area. The secondary channels are particularly important for Arctic grayling and mountain whitefish, and are obviously an important factor in the overall high fisheries productivity of aquatic systems in the area. Both fry and

juvenile fish have been observed extensively within such channels which, during periods of peak flow, may become the sole remaining holding and rearing zones for fish of all ages.

7.3.2. EPHEMERAL CHANNELS

"Ephemeral" channels are those which are at, or above, the level of rooted streambank vegetation. These channels contain water only during peak flood events, and are dry during periods of lesser discharge. Floods of sufficient magnitude to supply these channels do not necessarily occur every year, but when they do occur, ephemeral channels may provide rearing habitat for fish. During extreme peak floods, these channels may function as the sole remaining holding and rearing zones for fish of all ages. Where such channels are absent, or if fish cannot gain access to them, the fish may be displaced downstream by extreme floodwaters. The result may be either temporary displacement and then relocation, or permanent dislocation, which is usually accompanied by high rates of fish mortality.

7.3.3. SEMI-ISOLATED CHANNELS

"Semi-isolated" channels are recent meander cutoffs which retain a connection to the main channel at the downstream end. These channels contain water at all seasons, and at most times, it is possible for fish to move between them and the mainstem.

The water in semi-isolated channels originates mainly from ground seepage and surface runoff. Since the channels are of recent origin, they are frequently unvegetated, and feature identifiable cobble beds and former riffle and pool zones. During flood events, it is possible that water which is flowing across adjacent vegetated areas will enter these channels.

The main advantage of these areas is that their water quality is much better than that in the main river, where sediment levels may be higher, and temperatures much lower. They are very productive areas for the spawning and rearing of northern pike. Pike require shallow, warm waters in order to spawn. Young pike also rear in such habitat.

Towards late fall, the semi-isolated channels become inaccessible from the main river due to beaver dam construction. At this time, some fish are trapped within the channel but may overwinter there successfully.

7.3.4 ISOLATED CHANNELS

Isolated channels are not of recent origin, and have little or no connection to the main river. Their water supply is wholly derived from ground seepage and runoff from adjacent slopes. (Only during an extreme flood event might the influence of the mainstem be felt in such channels). The channels are, in fact, a series of beaver dams and shallow swamps. Due to ponding, water temperatures and nutrient levels are much higher than in the main river. Brook stickleback and finescale dace are found in these channels in the Tumbler Ridge area. It is also suspected that northern pike are present. The isolated channels are the last possible refuge areas for fish during a rare flood event of extremely large discharge.

7.4 HABITAT VARIABILITY

Habitat variability is one of the key factors which is considered in assessing relative fish production capability. A reach which displays a combination of mainstem, side-channels and back-channels can support much higher fish production levels than a simple, 'confined' reach.

Each fish species has three basic size classes - fry, juvenile and adult - each of which has specific habitat requirements. In the Tumbler Ridge area, there are nine fish species present, for a total of 27 species/size classes.

From the standpoint of fisheries management, further complications arise since changes in seasonal or daily climatic conditions result in changes in habitat requirements also. More specifically, fish change their location in response to changes in discharge, velocity, turbidity and temperature. There are also movements from areas of low to high food production, or from holding areas to spawning or feeding areas. Furthermore, fish tend to have a clumped distribution in rivers; rarely are they evenly distributed throughout a reach.

It must be stressed, therefore, that a variety of habitats in close proximity is an essential requirement for high-value fish production. It is especially important to note that this habitat variability is in large part made possible by the instability of channels and banks, and that attempts to stabilize or simplify river channels will reduce their capability for fish production.

7.5 DEVELOPMENTAL IMPACTS

The Tumbler Ridge area floodplain complex is thirteen kilometres in length and has the highest density of variable habitat of any reach within the first 170 kilometres of the Murray River system upstream of its confluence with the Pine River. For this reason, its importance as a fish production area cannot be over-emphasised.

The construction of a highway across the broadest part of the floodplain (near the Murray-Wolverine confluence - see Chapter Five, section 5.4. for discussion) would have major adverse consequences for fisheries. It appears that this highway would eliminate one-third of the available aquatic habitat in the Tumbler Ridge area.

If development takes place on the Murray River floodplain near Tumbler Ridge, it should occur on the east side of the river. The west side has a much higher productive capability for fish and should be protected.

On the basis of the maps and data which are now available and which have been summarized in this report, it is to be hoped that the impacts of future development proposals can be evaluated with relative accuracy in advance of construction.

7.6 SUMMARY

1. The fish populations which are present at Tumbler Ridge are considerable, and are capable of supporting sportsfishing activities.

2. The floodplain in the Tumbler Ridge area may be divided into four habitat zones, as shown in Figure 7.1.:
   (i) active channels;
   (ii) ephemeral channels;
   (iii) semi-isolated channels; and
   (iv) isolated channels.

   These zones variously comprise the critical habitats for fish species during normal changes in hydrologic and climatic regimes throughout the year.

3. Habitat variability is the key to high fisheries productivity in streams.

4. The Tumbler Ridge area has the highest density of variable floodplain habitat of any reach over the first 170 kilometres of the Murray River channel upstream of its confluence with the Pine River.

7.7 RECOMMENDATIONS

1. The Tumbler Ridge floodplain is a complex of various types of river channels. This diversity of channels is a function of channel instability, which is, in turn, the key to high fisheries productivity. Channel stabilization or major alterations to the floodplain could result in serious reductions in both habitat diversity and fisheries capability, and should not be entertained, except where unavoidable.

bibliography

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